INEXPENSIVE "BUILD-IT-YOURSELF" ANTENNAS FOR THE RADIO AMATEUR

A manual of practical, detailed data covering the design and construction of highly efficient, inexpensive antennas for the amateur bands that you can build yourself!

by William I. Orr, W6SAI/3A2AF Price $1.00

S-9 SIGNALS!

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FOREWORD

This Handbook is written for those amateurs who dream of fifty acre "antenna farms" studded with rhombic antennas and curtain arrays mounted on ninety foot towers but who are frustrated by unsympathetic neighbors, fifty foot lots, steely-eyed building inspectors and other grim factors that hamper sky-wire ambitions! May you all have *S-9 Signals!*

Designed with an eye to the thin purse, the antennas described in this Handbook have all been built, tested, and used by the author and his friends within the past few years. The antennas are simple, inexpensive, and best of all, THEY WORK! All dimensions are given, and no "guess work" is involved when you build and erect these antennas!

Your antenna is the most important part of your amateur station if you are looking for consistent QSO's and exciting DX contacts. The best and most expensive transmitter is but a useless toy if it is connected to a poor antenna. For a large hunk of money you can buy a good antenna— but this Handbook shows you how to construct good antennas by spending pennies instead of dollars! Many of the antennas described herein work efficiently on two or more amateur bands thus providing bonus multiband operation for the amateur restricted to a single "sky wire".

No matter how small your "antenna farm", nor how cramped your finances might be, *S-9 Signals!* will solve your antenna problem. A complete parts list for each antenna is provided in the back section of the Handbook. Good DX!

CHAPTER I

"Sugar-Coated" Antenna Theory

High-brow antenna theory and "slide rule" talk has no part in this Handbook! This is an "action" book, not a "study" book! You should read it with soldering iron in hand, and your "climbing boots" on! However, before work is started it is necessary to discuss some basic antenna terms that will continue to show up throughout the Handbook of which you should have a speaking knowledge. This chapter will handle this small task in jig-time. Read it!

The *antenna* is a device that converts electronic energy supplied by your transmitter to electromagnetic energy that may easily be radiated through space. Conversely, the antenna will capture electromagnetic energy from space and convert it to electronic energy that can be amplified and detected by your receiver. The simplest antenna is a piece of wire strung between two insulated supports. The efficiency of such a simple device is a function of the length of the wire as compared to the size (wavelength) of the radio wave it is supposed to receive or transmit. If the two are compatible in size the antenna will do a creditable job of plucking the radio signal out of the air or of radiating the signal into space.

All radio antennas regardless of their size, power gain, or other exotic qualities have many points in common which must be understood before the design and operation of any one particular type of antenna is studied. Let us briefly examine these points before passing on to greater projects.

Antenna Resonance

For any antenna there is one frequency called the *resonant frequency* at which various undesirable reactances of the antenna neutralize each other, leaving only the radiation resistance of the antenna to oppose the flow of current in the antenna. The resonant frequency of a simple antenna is a function of its physical length and location. When the antenna is in a

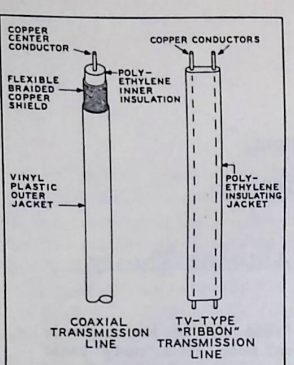


Fig. 1 The coaxial line is popular transmission line for amateur use, combining high efficiency with ease of installation. Two wire "TV-type" ribbon line is equally efficient and considerably cheaper than "coax", but has short life, especially when used in damp atmosphere, or where smoke and soot are prevalent. Line must be cleaned regularly for best results, and should be replaced every few years if weathering effects are noted. Either coaxial line or ribbon line work well for amateur use.

resonant condition a maximum value of current flows in it for a given amount of applied radio energy. Since radiation from the antenna is proportional to the current flowing in it, it is of the utmost importance that the antenna be *resonant* at the frequency of use. All antennas described in this Handbook are operated in a resonant condition which is established by the length of the antenna as related to the frequency of operation.

Energy Transfer to the Antenna

A resonant wire suspended well in the air makes a fine antenna but it is of little use unless some means are provided to conduct the radio energy from the antenna to the receiver or from the transmitter to the antenna. To accomplish this a "radio hose" or *transmission line* (figure 1) is employed to "pipe" the energy back and forth between the radio equipment and the antenna. The most popular types of line in use are the two-wire "TV-type ribbon line" and the coaxial cable. Although there are physical differences between these lines they all have a common property called the *characteristic impedance* of the line. This impedance is expressed in ohms and is determined by the physical and electrical properties of the line such as the size of the conductors, the spacing between them, and the type of insulating material used. Two common impedance values of lines are 52 ohms and 300 ohms.

Incidentally, this impedance notation does not mean that the line has an ohmic resistance equal to that value. In fact, efficient transmission lines

have a d.c. resistance less than one ohm or so. The characteristic impedance concept signifies in its simplest form that the line has been designed to be used with antennas that present that value of load *(radiation resistance)* to the line. To clarify this important concept let's look at the antenna once again.

Radiation Resistance

The radiation resistance of any antenna is expressed in ohms and may be defined as that value of real resistance which, when substituted for the antenna will dissipate in the form of heat the same amount of power as is radiated into space by the antenna. The actual value of radiation resistance of any antenna may be measured with appropriate instruments and usually runs in the neighborhood of 20 to 300 ohms for resonant antennas commonly used by amateurs. Radiation resistance is measured at that point of the antenna carrying the greatest value of current. In the case of the dipole this is the center point of the antenna.

Standing Wave Ratio (SWR)

The *standing wave ratio* is an abstract value that summarizes some of the other qualities of the antenna system. This ratio (abbreviated *SWR*) is an indication of the degree of mis-match between the radiation resistance of the antenna and the characteristic impedance of the transmission line. If these two quantities are equal in magnitude the SWR of the system (more commonly expressed as "the SWR on the line") is unity, or 1/1. If the line impedance is 52 ohms, for example, and the radiation resistance of the antenna is 70 ohms the SWR is 70/52, or 1.35/1. If the 52 ohm line is coupled to an antenna having a radiation resistance of 300 ohms the SWR value is 300/52, or 5.8/1. Everything else being equal the efficiency of energy transfer from transmitter to antenna and ease of transmitter loading are both best with low values (below 2/1) of standing wave ratio. The SWR will be at a minimum (1/1 ratio) when the antenna is in a resonant condition and when the radiation resistance of the antenna is equal to the characteristic impedance of the transmission line.

Balanced and Unbalanced Antennas

All antennas may be divided into two groups: *balanced antennas* and *unbalanced antennas*. Balanced antennas are those having feedpoints which must be supplied with radio energy that is balanced with respect to ground. Examples of this type of antenna are the dipole, the Cubical Quad, and the parasitic beam. The antenna is characterized by being physically symmetrical about the feed point. Unless some sort of matching device is

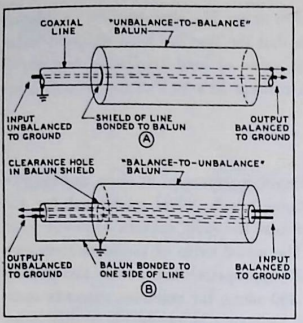


Fig. 2 The balun transformer is used to match a balanced line to an unbalanced line or vice-versa. Simplest balun consists of a quarter wave shield slipped over the transmission line and grounded to line at one end. Balun may be made of length of flexible, metallic braid for easy construction and low cost.

placed between the antenna and feed line a balanced antenna should always be fed with a balanced type of transmission line.

An example of the unbalanced antenna is the ground plane characterized by physical dissymmetry between the halves of the antenna. The feed points of such an antenna are unbalanced to ground. In the case of the ground plane one feed point is actually at ground potential. This antenna therefore should be fed with an unbalanced (coaxial) line which may have the outer shield grounded. A balanced (two wire) line may be used with an unbalanced antenna *provided* some form of matching device is placed between the antenna and the line. Mixing balanced antennas with unbalanced lines or vice-versa is bad engineering practice and can often lead to poor antenna system efficiency, loss of valuable power through line radiation, and sometimes creates troublesome TVI problems.

The *Balun transformer* (sometimes called a "tuning sleeve") may be employed as a matching device between balanced and unbalanced systems (figure 2). One form consists of a shield placed around the coaxial line, bonded to the outer conductor a quarter wavelength from the end of the line. The balun isolates the end of the outer conductor of the coaxial line, allowing a direct connection to be made to a balanced line. The balun may be placed at either the transmitter end or the radiator end of the antenna system.

Pi-Network Couplers

The majority of modern transmitters employ some form of pi-network coupler to match the amplifier tubes to the transmission line. The antennas described in this Handbook have been specifically designed to work with transmitters employing this simple and efficient type of output network.

CHAPTER II

The "Scotsman's" Dipole

The dipole antenna is an expensive installation when you purchase high cost coaxial cable for the feedline! Described here is an inexpensive dipole antenna system making use of inexpensive 75 ohm "TV-type" feedline in conjunction with a balancing device located at the "transmitter end" of the line. Feedline costs are slashed by this system and a more efficient installation is provided. For low cost and proven DX-ability, you can't beat the "Scotsman's" Dipole!

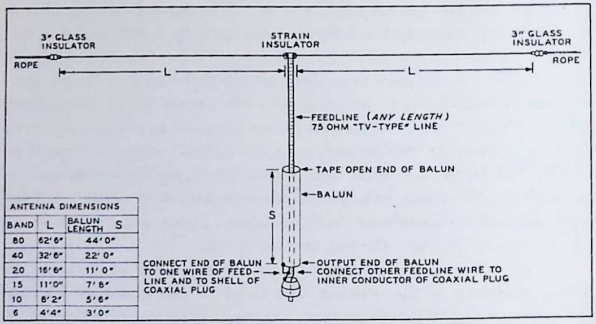
A center-fed antenna one half wavelength long is called a *dipole*. Used by thousands of stations the world over it is one of the most popular single band amateur antennas. The dipole is a balanced antenna and should be fed with a balanced transmission line. The great majority of modern transmitters however, employ unbalanced pi-network output circuits designed for use with coaxial lines. As a result the dipole is usually fed with a coaxial line instead of a balanced line when transmitters of this type are used. In addition to being the *wrong* type of line for this antenna the coaxial line is much more expensive than the balanced line. It is a waste of hard earned money to feed a dipole with 15-cent a foot coaxial cable when 75 ohm "TV-type" balanced ribbon line costing less than 2 cents a foot may be used in its place with equal or better efficiency. An inexpensive "balance to unbalance" balun transformer placed at the "bottom end" of the feedline will permit the balanced antenna system to be correctly matched to a single-ended pi-network type transmitter. Figure 3 shows the details of this inexpensive and efficient antenna system.

The dipole is resonated to the desired amateur band by trimming the length as shown in the drawing. The length of the balanced "TV-type" transmission line is unimportant as long as it is greater than one-quarter wavelength. An antenna of this type has a radiation resistance value falling between 60 and 80 ohms, the exact value depending upon the height of the wire above ground and the proximity and character of nearby objects.

A lower value of radiation resistance will be measured on the 80 meter band where the height of the average installation is low compared to the length of the antenna. The radiation resistance in any case can be satisfactorily matched by the inexpensive ribbon line.

Operation of the Balun

The outer surface of the outside conductor of a coaxial line is at ground potential while the inner conductor is well above ground potential. Both conductors of the balanced line however exhibit the same potential to ground under ideal conditions. The object of the balun is to produce a high impedance to ground on the outside of the outer conductor of the coaxial line at the point where it connects to one side of the balanced line; thereby converting the end of the coaxial line to a balanced condition. A simple balun that you can make consists of a flexible, braided shield slipped over the coaxial line. It is bonded to the outer shield of the line at one end and extends along the line a quarter wavelength. Another form of balun is made of a flexible shield placed over a balanced transmission line, extending along the line a quarter wavelength. At the bonded end of the line the two conductors are transformed to an unbalanced state by the action of the balun and a coaxial plug may be attached to the line at this point. The outer shell of the plug attaches to the balun shield and one wire of the line, with the opposite wire attached to the center pin of the plug. The first balun may be considered as an "unbalance to balance" device, and the latter a "balance to unbalance" unit (figure 2, chapter 1).



ANTENNA DIMENSIONS

BAND	L	BALUN LENGTH S
80	52' 6"	44' 0"
40	32' 6"	22' 0"
20	16' 6"	11' 0"
15	11' 0"	7' 8"
10	8' 2"	5' 6"
6	4' 4"	3' 0"

Fig. 3 Dipole with "ribbon" feedline and Balun makes efficient antenna for any band. Complete list of parts for construction is at end of Handbook. Antenna may be used for both transmission and reception with high efficiency.

Constructing the Antenna

Dimensions of the antenna suitable for the amateur bands are given in figure 3. The dipole can be made of #12 enamel coated wire (you can use ordinary stranded antenna wire if you do not live near the seacoast or near industrial areas where salt spray or smog will corrode the wires). The 80 meter antenna should be made of "hard drawn" copper wire to prevent stretching and sagging in heavy winds. Each end of the antenna wire is cleaned of insulation, looped through the insulator hole, twisted back upon itself and securely soldered. A strain insulator is placed at the center of the antenna with the wires passing through the overlapping holes and looped back upon themselves. The wires of the feedline are stripped of insulation and passed through the holes of the center insulator and wrapped about each antenna wire. The center joints are now soldered with a hot iron.

The antenna should be erected as high as possible (not less than 20 feet above the ground) and the feedline must drop vertically from the center of the antenna and not be led away parallel to the dipole. Best results will be obtained when the antenna is forty or fifty feet high and well in the clear.

Building the Balun

The last job is to make a simple balun of flexible, copper braid shielding, ⅜" diameter. Cut the braid to the length shown in figure 3 and slip it over the "transmitter end" of the balanced line. Smooth it out and tape it in position every foot or so with vinyl electrical tape. In addition, tape the open end of the balun to cover up the wire "whiskers." After it is in position remeasure it to make certain it has not stretched in length. If this is the case retrim it to the proper length. No connection is made between the balun and the line at the end opposite the coaxial plug. Next, solder a short length of bare copper wire around the output end (plug end) of the balun and connect this lead to one wire of the balanced transmission line. Be careful not to melt the insulation of the line during this operation. Finally, place a coaxial plug on the line at the point where the line and balun are joined. The transmission line wire soldered to the balun shield is soldered to the shell of the plug and the other wire is soldered to the center pin of the plug. The balun is now complete.

It is a good idea to wrap the balun with vinyl electrical tape for its entire length to protect the fine wires of the shield. The unit may now be coiled up behind the transmitter if desired. Alternatively, it may be run out the window to form part of the transmission line. If the balun is placed outdoors, taping is a "must" to prevent moisture from collecting within the braid.

CHAPTER III

Multi-band Dipole Antennas

The simple dipole antenna is a star performer on a single amateur band. It is a problem, however, to erect more than one dipole when you live on a small city lot! Shown in this chapter are simple multi-band dipoles capable of operating on several amateur bands. The multi-band dipoles are easy to build, restricted in size, require but a single feedline, and cost but little more than a single band dipole. You can't get something for nothing, but in this case you can get a good multi-band antenna for next to nothing!

The simple dipole antenna operating at its natural resonant frequency presents a low impedance load of approximately 72 ohms at the center feed point. As the frequency operation is removed from the resonant frequency the impedance of the dipole changes sharply, and at frequencies far removed from the natural frequency the terminating impedance contains such a high value of reactance that it is nearly impossible to couple any energy from a low impedance feedline to the antenna. This means that the dipole is a one-band antenna and will refuse to radiate much energy on any other amateur band. It is possible nevertheless to connect several dipoles in parallel at the feedpoint and energize them with one transmission line. Only one dipole will effectively function at one time—the dipole that is resonant at the frequency of the exciting energy supplied by the transmitter. For reception the multi-band dipole functions equally well on the various bands to which the separate dipoles are tuned.

It is true that the unused dipoles couple some undesirable reactance into the transmission line which would not be present when only a single dipole is employed. However this is a small price to pay for the convenience of operating a single "sky wire" system on several bands! A simple balun placed on the feedline at the "transmitter end" will help to eliminate the effects of unwanted reactance and will permit the multi-band dipole to be used with any modern pi-network type transmitter. Several versions of this antenna will be described, one of which will fit into your yard no matter how small it might be!

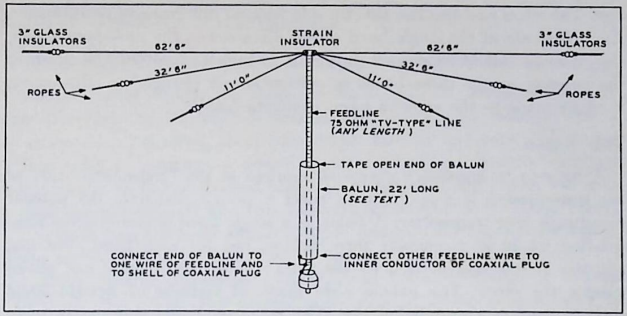

3" GLASS INSULATORS
62' 6"
STRAIN INSULATOR
62' 6"
3" GLASS INSULATORS
ROPES
32' 6"
11' 0"
11' 0"
32' 6"
ROPES
FEEDLINE 75 OHM "TV-TYPE" LINE (ANY LENGTH)
TAPE OPEN END OF BALUN
BALUN, 22' LONG (SEE TEXT)
CONNECT END OF BALUN TO ONE WIRE OF FEEDLINE AND TO SHELL OF COAXIAL PLUG
CONNECT OTHER FEEDLINE WIRE TO INNER CONDUCTOR OF COAXIAL PLUG

Fig. 4 Multiband antenna works well on 80, 40, and 15 meters. No traps or switching circuits are necessary as antenna is self-resonant at three frequencies. Balun is used to permit balanced antenna to work with pi-network transmitter.

A Multi-band Novice Dipole for 80, 40 and 15 meters

A multi-band dipole suitable for Novice work in the 80, 40, and 15 meter bands is shown in figure 4. Three dipoles are joined at the center insulator and fed in parallel with a single "TV-type" 75 ohm balanced transmission line. In passing, it should be noted that the 40 meter (7 mc) dipole is *almost* resonant in the 21 mc (fifteen meter) Novice band. It is tempting, therefore to eliminate the 15 meter dipole and trust the 7 mc antenna to operate on its third harmonic. This is not recommended since the harmonic resonance point of the 40 meter dipole falls outside the limits of the 21 mc band. Use three dipoles and play safe! With the arrangement shown in the illustration the SWR on the transmission line is low enough to permit proper transmitter operation with a minimum of circuit loss.

Constructing the Antenna.

The six wires of the antenna are cut to length allowing enough extra wire at each end to loop around the various insulators. Scrape the insulation from the ends of the wires and wrap them around the insulators, soldering all joints after the antenna is completely assembled. A strain insulator is used at the center of the antenna. The two wires of the 75 ohm "TV-type" ribbon feedline are passed through the holes of the center insulator and soldered to the two halves of the antenna. The complete installation is supported by the 80 meter dipole with the 40 and 15 meter antennas draped beneath the longer wires. The spacing between the wires of each half of the antenna is not critical and may be of the order of one to five

feet. The wires can also run side by side with no difference in performance. As in the case of the single band dipole discussed in the previous chapter, this antenna should be erected in the air as high as possible. Operation of the antenna on the three bands is automatic—no changes or adjustments need be made to the antenna when changing bands.

The Balun

A balance to unbalance device is required at the "transmitter end" of the transmission line in order to effect a proper match to the popular pi-network type transmitter. A balun is a single band device and the ideal solution would be to employ three baluns, one for each band. The first antenna of this type erected by the author used three baluns, one placed outside the other. The baluns were made of sections of flexible braid slipped over the transmission line. The 80 meter balun was put in place first, then covered with a single layer of electrical tape. The 40 meter balun was placed over the 80 meter one and wrapped with a second layer of tape. Finally, the 15 meter balun was put atop the 40 meter one and covered with a third layer of tape. All baluns were connected together at the "transmitter end" of the line at which point a coaxial plug was affixed. During operation of the antenna it was found that the 40 meter balun would do an acceptable job of providing balance to unbalance transformation at 80 meters even though it was extremely short at the latter frequency. In addition the 40 meter balun resonated at its third harmonic for 21 mc operation, eliminating the need for the shorter balun. The final balun assembly is shown in figure 4 consisting of a single 40 meter balun which

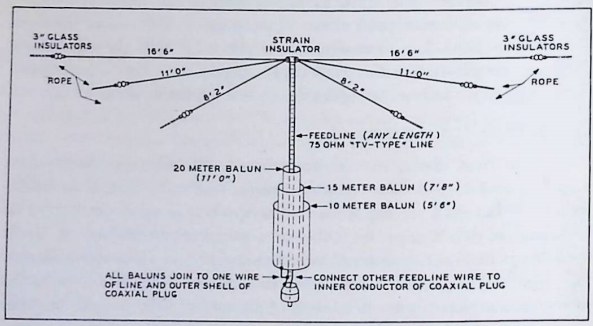


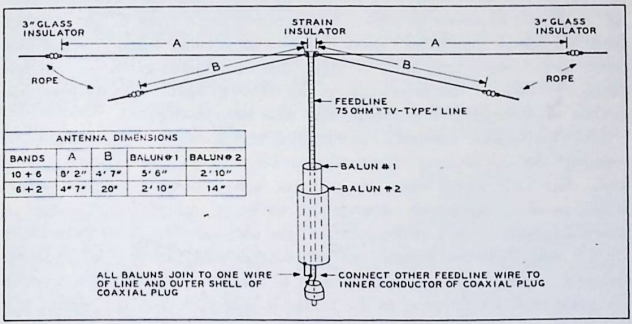
Fig. 5 DX dipole for 20, 15, and 10 meter operation requires three Baluns for proper operation. A complete parts list is given at back of this Handbook.

performs effectively on all three bands. Construction of the balun is as described in chapter 2 of this Handbook.

A Multi-band Dipole for 14, 21, and 28 Megacycles

The three most popular DX bands are 20, 15, and 10 meters. For a large sum of money the DX-minded amateur can purchase or build a 3-band beam capable of covering these frequencies. For far less outlay of money it is possible to construct a 3-band dipole that will perform in excellent fashion on these bands. Erected high and in the clear the dipole will give a good account of itself and will be worth its weight in DX QSL cards!

Shown in figure 5 is an antenna system designed for these three bands. Three tuned dipoles are connected in parallel at the feed point and are fed with a two wire transmission line made of a random length of 75 ohm "TV-type" ribbon line. The antenna is constructed in the same manner as the previously described multi-band dipole. It is necessary, however, to employ three separate baluns at the "transmitter end" of the feedline as the lucky combination of circumstances that permits one balun to suffice for 80-40-15 meter operation does not appear in this antenna configuration. The 20 meter balun is made first and slipped over the line. It is wrapped with a layer of vinyl electrical tape, over which the 15 meter balun is placed. A second layer of tape is wound spirally over the balun, atop which is placed the 10 meter balun. A final layer of tape is placed over the last balun. All baluns are connected together at the "transmitter end"



ANTENNA DIMENSIONS

BANDS	A	B	BALUN #1	BALUN #2
10 + 6	8' 2"	4' 7"	5' 6"	2' 10"
6 + 2	4" 7"	20"	2' 10"	14"

Fig. 6 Multiband dipole principle may be adapted for use on 10, 6, and 2 meter bands. Dipole for 28 and 50 mc operation is only 16'4" in length, and 50 and 144 mc antenna is only 9'2" long. Wires A and B should be separated about a foot at their extremities. Antenna must be mounted well in the clear and as high as possible for best results on long distance contacts.

of the line and the common joint is attached to the outer shell of the coaxial plug. The "free" wire of the transmission line is attached to the center conductor of the plug. The insulated balun assembly may be coiled behind the transmitter, or may pass out the window as part of the transmission line.

A Multi-band Dipole for the VHF Bands

A dual dipole may be used for 2 and 6 meter operation with good success (figure 6). A common 75 ohm "TV-type" feedline with dual baluns makes up the feed system. Construction of this antenna follows the same pattern as that of the other versions described in this chapter. In like manner a 6 meter and 10 meter antenna may be composed of the proper dipoles for these bands, using parallel wire feed line and appropriate baluns placed at the "transmitter end" of the line. In each case the lower frequency balun should be placed next to the transmission line with the higher frequency balun slipped over it.

A Multi-band Dipole for 40, 20, 15, and 10 Meters

If 80 meter operation is not contemplated the multi-band dipole may be reduced in length and complexity. Advantage may be taken of the fact that four wire vinyl plastic cable (used for TV antenna rotator control) may be purchased for a few cents a foot. Four dipoles for these bands may therefore be made of a single piece of this flat cable. Moreover, if the builder is foxy, he can save money by purchasing a forty-five foot length of cable and cutting it as shown in figure 7, thus producing a sixty-six foot antenna from the shorter length of cable! Purists and antenna engineers may look down their nose at the idea of using multi-conductor cable for multiple dipoles in view of the proximity of the wires to each other, however the system works well and is inexpensive and unobtrusive!

The vinyl plastic insulation is moulded about each wire permitting the "zig-zag" cut shown in the illustration to be made with ease, using a sharp knife. The forty meter wires are each cut a foot longer than the resonant length to allow six inches at each end to wrap around the insulators. A strain insulator is used at the center of the antenna. The "far" ends of the 20, 15, and 10 meter dipoles are left floating and the "inside" ends are stripped, twisted together and soldered to the 40 meter dipole sections at the point they are attached to the center insulator. If you are careful it is possible to push back the vinyl insulation on the tips of the 20, 15, and 10 meter dipoles exposing about ¼-inch of the conductor. The end bit should be snipped from each wire and the insulation permitted to expand past the end of the wire. A quick touch of a clean soldering iron tip to the plastic will seal the end providing a water-proof seal for the end of

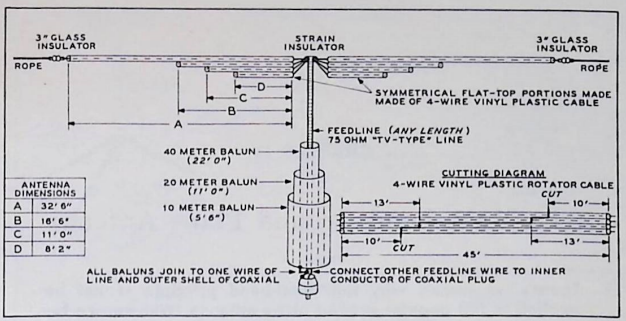


Fig. 7 Multiband dipole for 40, 20, 15, and 10 meter operation is made of inexpensive length of four wire vinyl plastic cable. A forty-five foot length is cut in two as shown at upper right to make two thirty-five foot sections.

each individual dipole wire. The last step is to attach the feedline and make the balun assembly for the far end of the feeder. It is necessary to employ 40, 20, and 10 meter baluns (made as described in the previous sections) to allow good matching between the system and the pi-network transmitter. The 15 meter balun may be omitted as the 40 meter balun does a good job over the 21 mc range.

A multi-band dipole of this type may be attached to a simple 80 meter dipole providing a somewhat less cumbersome installation than that made up of individual wires (figure 8). Either type works well, so take your choice.

A word to the wise: Any multi-band antenna will radiate the harmonics generated by your transmitter! *Be sure* these harmonics are eliminated before they reach the antenna. An antenna tuner will do the job for you.

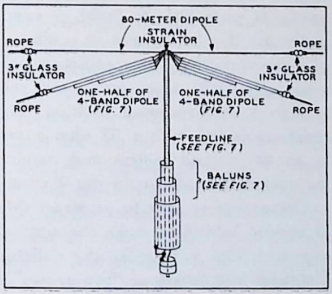


Fig. 8 Multiband vinyl dipole may be attached to 80 meter dipole to make an all-band antenna capable of operation from 80 to 10 meters. Be sure your transmitter is free of harmonics before you use any multiband antenna. Simple antenna tuner will eliminate the harmonics before they reach your antenna.

CHAPTER IV

The Multi-band Ground Plane Antenna

There's no reason why the multi-band principle cannot be applied to the popular ground plane antenna. Well-known for its ability to grab DX, the G-P can be modified for red-hot operation on 20, 15, and 10 meters with little outlay of time or cash! As a bonus, you can also have 40 or 80 meter operation if you juggle the length of the feedline a bit! Here's how!

The vertical ground plane antenna provides a low angle of radiation that makes it a good DX antenna for any amateur band. Placing two ground planes in one back yard is a complicated task, as the amateur wishing two band operation is liable to hang himself as he moves about in the snarl of radial wires and feeders! Once again, the multi-band principle used so effectively with the dipole comes to the rescue, permitting two or more ground plane elements to be fed with a single feeder and taking advantage of a simple radial system made up of multi-conductor cable. Here are the details of this compact and efficient antenna system.

The DX Ground Plane for 20, 15, and 10 Meters

Shown in figure 9 is a multi-band ground plane for the popular DX bands. It costs little to build, is easy to assemble, and simple to get up in the air if a handy tree or rooftop is nearby. The antenna is composed of three vertical ¼-wave radiators fed in parallel at the base, working in conjunction with three multi-band radials which extend below the radiators in a semi-reclining position. The juncture of the radials and the radiators is fed with a 52 ohm coaxial line. The ground plane antenna is an unbalanced system and requires an unbalanced feedline such as the coaxial line shown in the illustration.

The expensive way to construct this antenna is to buy three pieces of aluminum tubing to make the vertical radiators. A far simpler and less expensive idea is to make the radiators of #12 copper wire strung along a sixteen foot length of "two-by-two" lumber. It is possible, moreover, to

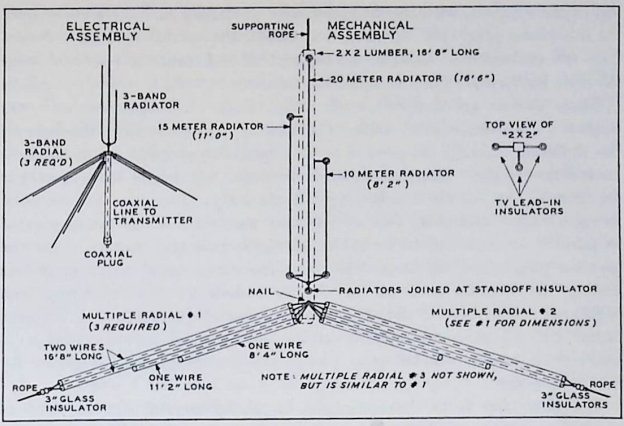

ELECTRICAL ASSEMBLY
SUPPORTING ROPE
MECHANICAL ASSEMBLY
2 X 2 LUMBER, 18' 8" LONG
20 METER RADIATOR (16' 6")
3-BAND RADIATOR
15 METER RADIATOR (11' 0")
3-BAND RADIAL (3 REQ'D)
TOP VIEW OF "2 X 2"
10 METER RADIATOR (8' 2")
TV LEAD-IN INSULATORS
COAXIAL LINE TO TRANSMITTER
COAXIAL PLUG
NAIL
RADIATORS JOINED AT STANDOFF INSULATOR
MULTIPLE RADIAL # 1 (3 REQUIRED)
MULTIPLE RADIAL # 2 (SEE # 1 FOR DIMENSIONS)
TWO WIRES 16' 8" LONG
ONE WIRE 8' 4" LONG
ONE WIRE 11' 2" LONG
NOTE: MULTIPLE RADIAL # 3 NOT SHOWN, BUT IS SIMILAR TO # 1
ROPE
ROPE
3" GLASS INSULATOR
3" GLASS INSULATORS

Fig. 9 Multiband antenna principle may be applied to ground antenna as shown here. Low angle of radiation makes this antenna ideal for DX operation!

attach a rope to the top of the wooden support, toss the rope over a high branch in a tree and pull the ground plane into operating position high in the air without lifting your foot from the ground! (This scheme appeals mightily to the author who has spent more hours scrambling in trees and crawling up towers than he cares to admit!)

Antenna Construction

The antenna support is a sixteen foot length of 2″ x 2″ lumber (which usually measures about 1½″ x 1½″ on a side). Choose a straight, dry piece and give it two coats of outdoor varnish before you start to work. The radiator wires are cut to length, allowing a few inches on each end, and are fixed in position on the wooden support by means of 7½″ wood-screw type TV lead-in insulators. The insulators are run into the support as shown in the illustration and the radiator wires are passed through the polyethylene inserts. Tie the wire to the insulator with cord at each termination. The bottom ends of the radiators are cleaned of insulation, twisted together and finally fastened to a small porcelain stand-off insulator screwed to the base of the pole. If you are lucky, you can pick out a "sixteen foot" length of lumber that actually measures about 16′8″ long: long enough to take the full length of the 20 meter radiator wire. A shorter piece of lumber requires that the top TV lead-in insulator be run into the

top of the support, with the 20 meter wire gracefully making a curve over the top of the pole. This will in no way hinder the operation of the antenna. You can make a little hook in the top end of each radiator wire and wrap the wire with vinyl tape just above the insulator to hold it securely in place.

Three radials are required, each radial made of inexpensive four conductor TV rotator control cable. The radials run down from the base of the radiators towards the ground at an angle of approximately 45 degrees. In addition to their electrical function they also act as guy wires to steady the bottom end of the wooden support. As only three wires are required in each radial assembly, two of the four conductor wires are connected in parallel at each end to form the 20 meter radial, since these have the greatest physical strain upon them. Cut the other radial wires as shown, sealing the various ends of the shorter radials by the "soldering iron technique" described in detail in the previous chapter. Finally, the three radial sets are soldered together at the antenna end and anchored to a nail driven in the wooden pole just below the terminating insulator for the radiators.

The next step is to determine the length of coaxial line required to reach from the base of the antenna assembly to your shack. You can use the less-costly RG-58/U 53 ohm cable for transmitter power under 250 watts, and the larger RG-8/U 52 ohm cable for higher power. Carefully strip the outer insulation from one end of the cable for about six inches taking care not to damage the tiny wires of the outer shield. Now, using a small nail carefully unbraid the shield as far back as the outer insulation, twisting the wires into a single conductor once they are free of the center insulation. This braided "pig tail" will support the weight of the line. Finally, trim the insulating core from the center conductor for a distance of four inches and wrap the whole joint firmly with a short length of vinyl electrical tape. The surest way to ruin a length of coaxial line is to let moisture seep in the open end between the braid and the inner core of insulation. A few inches of tape will prevent this and your coax line will last to a ripe old age with little deterioration. Solder the "pig tail" to the junction of the radials and solder the inner conductor of the line to the termination point of the vertical radiators and your antenna is completed. No baluns of any type are required with this system.

Antenna Installation

If you have a handy tree, a flat roof, or a convenient chimney your troubles are almost over! It is possible to hang the antenna by its tip from the upper tree branches, like a gigantic plastic icicle on a Christmas tree. The support will dangle like a pendulum, stabilized at the bottom end by the three radial assemblies. To accomplish an installation of this type all

that is required is a tree, some string, a sturdy rope, and a steady eye and strong arm. Tie a small rock to the string and (being observant of nearby windows, etc.) toss the string over the highest branches of the tree, letting the string settle in a crotch of the branches. Poor, winded W6SAI can only seem to toss the stone upwards of thirty feet or so but young, virile, W6WWQ achieved a record toss of sixty feet into a tall eucalyptus tree. Once the string is safely over the branch and the rock down again at ground level the heavier rope may be pulled over the branch with ease. With the top of the ground plane firmly tied to one end of the rope it may be hoisted to the uppermost branches with little effort. Care should be taken to guide the antenna through the tree branches on its ascent, protecting the wires of the assembly from being snarled or snagged during the trip. Jockey the antenna into a vertical position clear of leaves and branches and steady the base by means of the radials. Slope the three vinyl coated radials down at some angle between 30 and 60 degrees to the horizontal and tie them off to nearby branches and your job is done.

If you have a flat roof on your house or garage a slightly different installation technique may be used. The bottom of the support may be spliced to a "Christmas tree stand" type of mounting with the base of the antenna supported about six feet or so above the roof, guyed in place by the radials. Television mounts, clamps and other antenna accessories will come in handy, especially if you plan to fasten the antenna to a chimney. With a little ingenuity you can also fasten the assembly to a vent pipe on the roof of your house, or to a sturdy metal gutter pipe. Keep the base of the antenna high enough so that you can slope the radials downwards from the bottom of the radiator as shown in the sketch.

Bonus Operation on 40 or 80 Meters

Yes, it is possible to operate this antenna system on either 40 or 80 meters provided you choose the right length of coaxial line to span the distance between antenna and transmitter! It is merely necessary to jumper the outer conductor of the coax to the inner conductor at the transmitter end of the line, connecting the whole "shooting works" to the output terminal (inner conductor of the coaxial socket) on your transmitter. Run a short, heavy wire from the chassis of the transmitter to a nearby water pipe. The antenna and coaxial line will now act as an end-fed quarter wave Marconi antenna with the shield of the coaxial line doing the radiating and the ground plane antenna merely contributing a bit of top loading effect. For 40 meter operation the coaxial line should be about 50 feet long, and for 80 meter operation it should be approximately 106 feet in length. There is nothing mystical in these dimensions and you might find that some intermediate length will work well on both bands for you.

CHAPTER V

The "Cobra" Ground Plane for 10 or 6 Meters

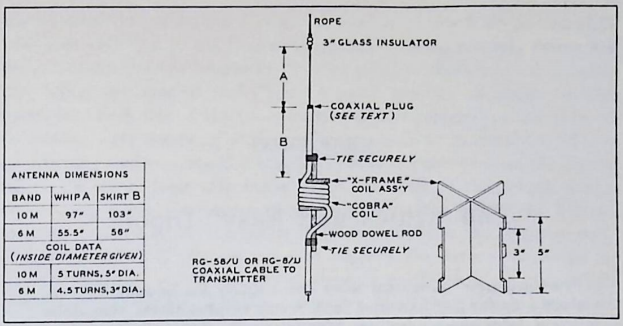
Are you interested in a simple antenna that costs practically nothing, that can be built in a few minutes, and that provides good performance on the higher frequency bands? Then, the "Cobra" is the antenna for you! A "Field Day" special, this fancifully-named antenna was christened by an enthusiastic user who saw in the decoupling coil and vertical section a resemblance to the weaving reptile of the snake charmer! What an imagination!

The "Cobra" array is a simplified vertical antenna that replaces the radial sections of the normal ground plane with a decoupling coil made of a section of the transmission line. Contrary to popular thought, the angle of radiation of a ground plane is determined principally by the height above ground of the installation, the radials serving more as decoupling devices for the transmission line than as a true "reference ground" point. For operation in the 28—54 mc range the radials may be exchanged for a simple and economical decoupling coil with little difference in antenna performance. Strung high in a tree the "Cobra" whip provides good communication efficiency, considering its size and cost.

Antenna Assembly

The complete "Cobra" is shown in figure 10. It consists of a quarter wave whip suspended at the top by an insulator and length of rope hung from a convenient tree or other support. The whip is fed at the lower end by a low impedance coaxial transmission line. A quarter wave section of this line serves as a "skirt" for the whip, actually making the antenna a modified vertical dipole array. The lower end of the skirt is decoupled from the remainder of the line by means of a resonant decoupling coil formed from a coiled portion of the transmission line.

The decoupling coil is wound on an "X-frame" made of thin plywood or other nonmetallic material. You can even use stiff cardboard for this purpose. A wooden dowel rod or post passes through the center of the



ANTENNA DIMENSIONS		
BAND	WHIP A	SKIRT B
10 M	97"	103"
6 M	55.5"	56"
COIL DATA (INSIDE DIAMETER GIVEN)		
10 M	5 TURNS, 5" DIA.	
6 M	4.5 TURNS, 3" DIA.	

Fig. 10 Cobra ground plane antenna substitutes a skirt and decoupling coil for the radial wires of simple ground plane. Cobra works on 10 or 6 meter band. Coil form is two pieces of plywood, 5" long and 6" wide. Slots are ½" deep.

coil and the X-frame is nailed to it. The ends of the coil are firmly lashed to the dowel as shown in the illustration to provide a rigid support for the coil form and also to take the weight of the transmission line off the coil itself. The coaxial line above the coil is trimmed to the skirt length for the band of operation and a coaxial plug *(type PL-259-A)* is placed on the end of the line. The threaded retainer ring is not used and it should be discarded before the plug is soldered in place. Carefully solder the braid to the outer shell of the plug *through* the four small solder holes in the plug. Use a *very* hot iron with a small tip. Do this operation quickly so as not to melt the insulation of the coaxial line. Finally, solder the center wire of the cable to the pin of the plug.

Next, cut a piece of wire to the correct length for the whip, allowing a few spare inches for terminating the top of the antenna to the supporting insulator. Solder one end of the whip to the center pin of the coaxial plug, wrapping the wire several times around the pin to make a good mechanical joint. Attach the top insulator to the whip at the correct point to resonate the whip, wrap the wire back upon itself and solder the joint.

The last step is to wrap the center joint securely with vinyl tape to waterproof it. When completed, the "Cobra" can be hoisted into a handy tree with the aid of the stone, string, and rope trick mentioned earlier in the last chapter. The whip, skirt, and decoupling coil should lie in a vertical line, one below the other for best operation. Since the antenna is an unbalanced system completely isolated from the transmission line by the action of the coil, no balun is required at the "transmitter end" of the line. Place a coaxial connector on the line and connect it to your transmitter.

CHAPTER VI

The "Quick and Easy" Dipole

"Twisted pair" electrical wire can usually be bought for less than a dollar per hundred feet. Many surplus stores also stock "field telephone wire" in 500 foot rolls that sell for a few dollars. Here's how to make an inexpensive low-loss antenna and feed system with this wire. Excellent for emergency use or Field day, this dipole array can be built and placed in operation in a few minutes!

Ordinary "twisted pair" electrical wire usually consists of two copper wires having rubber or fabric insulation. When used as a feeder this type of line has considerable loss. At a frequency of 5 mc, for example, a 100 foot section of line showed a loss of 3 decibels. When the line was soaked with water the losses rose considerably.

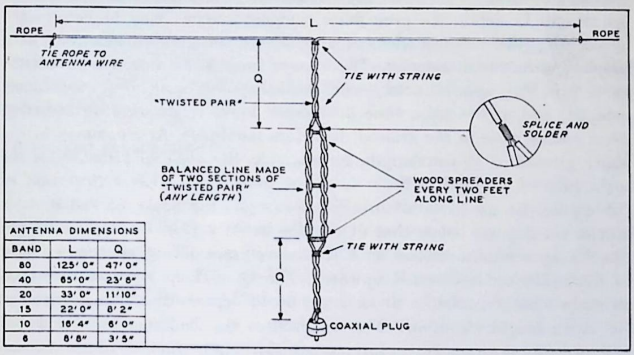
A simple way to overcome these high losses is to employ the twisted pair line as one side of a two wire transmission line, as shown in figure 11. A satisfactory two wire balanced line can be made by tying two "twisted pairs" to wooden feeder spreaders or other suitable insulators. The spreaders are two inches long and should be spaced about two feet apart along the length of the line. The wires of each "twisted pair" are shorted together at the ends to form one conductor. A line constructed in this manner has an impedance of about 400 ohms. It is possible to match this line to a dipole antenna and to your transmitter by making two quarter wave matching sections of "twisted pair," inserting one between the line and the center terminals of the dipole and the other between the line and the coaxial antenna terminal of your transmitter. The antenna itself can be made of untwisted "twisted pair," and can actually be a continuation of the top quarter wave matching section.

Constructing the Antenna

Make the two wire line first. Cut two sections of "twisted pair" to the length needed to reach from antenna to transmitter and string them be-

tween convenient points. Cut a sufficient number of wood blocks and drill holes near each end of the blocks. Using heavy string securely fasten the blocks between the two lengths of "twisted pair" to form a two conductor line. Solder the ends of each "twisted pair" together as shown in the illustration. Each side of the two wire line is now soldered to one wire of the quarter wave matching sections. The dipole is a continuation of the top matching section. Untwist a length of "twisted pair" to form the dipole and tie the center joint with heavy twine. The rest of this length forms the matching section. A coaxial plug is placed on the end of the bottom matching section and the antenna is ready for use. You can dispense with antenna insulators if you use rope to support the array. No balun is employed with this simple antenna as shown but its use is recommended, especially with the higher frequency antennas. Make the balun as described earlier of a length of flexible, shield braid long enough to reach from the coaxial plug to within an inch or two of the splice between the lower matching section and the two wire line. Solder the balun shield to the outer shell of the coaxial plug. In a pinch, you can dispense with the balun entirely.

System losses are quite low for this antenna. As measured in a 10 meter assembly, a 100 foot length of two wire "twisted pair" line and two matching sections produced an over-all loss of 2 decibels when dry and 3 decibels when wet. At the lower frequencies the loss will be proportionately less.



ANTENNA DIMENSIONS		
BAND	L	Q
80	125' 0"	47' 0"
40	65' 0"	23' 6"
20	33' 0"	11' 10"
15	22' 0"	8' 2"
10	16' 4"	6' 0"
6	8' 8"	3' 5"

Fig. 11 Simple dipole for emergency service or "Field Day" operation can be made out of "twisted pair" electrical wire. Two quarter wave "Q-sections" match the dipole to random length of two wire transmission line made of two sections of twisted pair. The antenna insulators are omitted for lowest cost.

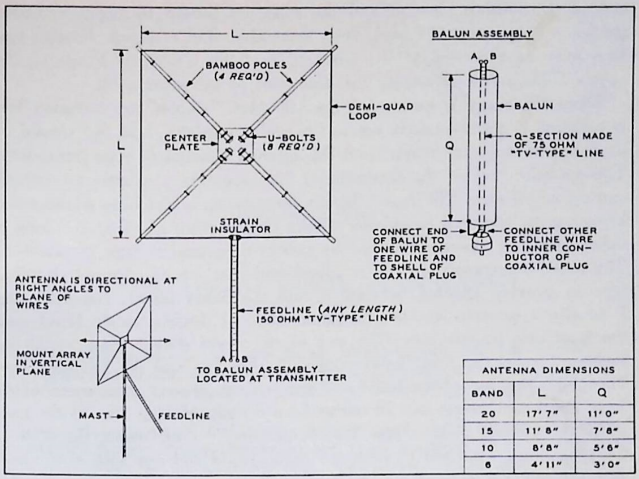
CHAPTER VII

The "Demi-Quad" Beam Antenna

Here's a simple beam antenna for the DX-hound! Small in size and easy to build, this antenna will pay off in better QSO's and less QRM. Best of all, it can be built and erected with no critical tuning adjustments. It has a bidirectional pattern similar to a dipole but provides superior performance, especially in locations where it is not possible to erect your antenna high in the air. Construction costs are comfortably low.

The popular Cubical Quad antenna is composed of a square loop acting as a radiator closely coupled to a second loop serving as a parasitic reflector. The Quad is a compact beam antenna since it is only one quarter wavelength wide, one quarter wavelength high, and less than one quarter wavelength in depth. An even more compact antenna may be constructed by omitting the reflector element and merely using the driven loop as a simple bidirectional antenna. The square loop is an interesting radiator as it provides approximately one decibel power gain over the dipole antenna, and at the same time provides a lower angle of wave radiation *when placed close to the ground* than does the dipole. At a common height above ground of ½-wavelength, for example, the angle of radiation of the main lobe of a Quad radiator is about four degrees lower than that of the dipole. At an elevation of ⅜ wavelength the angle of radiation is almost ten degrees below that of the dipole. At a height of ¼-wavelength the dipole is almost useless as a shortwave transmitting antenna as most of the radiation is directed upwards. The Quad loop however maintains its main lobe of radiation at an angle of 40 degrees above the horizon at the same height elevation! This emphasizes the fact that the Quad will still provide satisfactory performance under circumstances where the antenna cannot be elevated high in the air.

The single Quad loop is a low-Q radiator, exhibiting modest reactance when used off-frequency and is well suited to general coverage operation. The radiation resistance is high, falling in the neighborhood of 150 ohms.


L
BAMBOO POLES (4 REQ'D)
DEMI-QUAD LOOP
CENTER PLATE
U-BOLTS (8 REQ'D)
STRAIN INSULATOR
BALUN ASSEMBLY
A B
BALUN
Q-SECTION MADE OF 75 OHM "TV-TYPE" LINE
Q
CONNECT END OF BALUN TO ONE WIRE OF FEEDLINE AND TO SHELL OF COAXIAL PLUG
CONNECT OTHER FEEDLINE WIRE TO INNER CONDUCTOR OF COAXIAL PLUG
ANTENNA IS DIRECTIONAL AT RIGHT ANGLES TO PLANE OF WIRES
FEEDLINE (ANY LENGTH) 150 OHM "TV-TYPE" LINE
MOUNT ARRAY IN VERTICAL PLANE
A B
TO BALUN ASSEMBLY LOCATED AT TRANSMITTER
MAST
FEEDLINE

ANTENNA DIMENSIONS

BAND	L	Q
20	17' 7"	11' 0"
15	11' 8"	7' 8"
10	8' 8"	5' 6"
6	4' 11"	3' 0"

Fig. 12 Single Quad loop makes an effective bidirectional antenna. Small and light, the Demi-Quad provides lower angle of radiation than dipole when both antennas are placed near the ground. Demi-Quad frame is made of light bamboo.

The pattern is bidirectional requiring only a half-turn of the antenna to provide world wide coverage. The array is light, inexpensive to build and may be fed with "TV-type" balanced ribbon line. All in all, it is a lot of antenna for the money and construction time involved!

Antenna Construction

The completed "Demi-Quad" is shown in figure 12. It consists of a vertical square of wire one quarter wavelength on a leg mounted on a bamboo framework. The lower horizontal section of the loop is broken at the center for a 150 ohm balanced "TV-type" feedline which is coupled to your transmitter with a modified balun and matching transformer.

The supporting frame of the antenna is made of four lengths of bamboo attached at their butt ends to a plywood center plate by means of galvanized U-bolts. Each pole is wrapped with vinyl plastic tape between the joints to enhance the strength and to retard splitting of the wood. In addition each pole is given two coats of waterproof varnish. Small holes are drilled as shown near the tips of each bamboo pole to pass the antenna wire which is threaded through the poles after assembly of the frame. Each

end of the wire is cleaned and the ends are passed through the center insulator holes, wrapped back upon themselves and soldered. Enough tension may be imparted to the wires to keep them taut by loosening the center U-bolts and spreading the butt ends of the poles a bit.

When the array is assembled the 150 ohm "ribbon" transmission line is soldered to the wire ends across the center insulator. The line should be of sufficient length to reach from the antenna location to your transmitter. The opposite end of the transmission line requires a quarter wavelength section of 75 ohm "TV-type" line to function as a matching transformer, bringing the terminal impedance of the system down to about 40 ohms, a value that may readily matched by common pi-network type transmitters. The matching transformer is wrapped with two layers of vinyl electrical tape to provide spacing between it and the balun shield. The final step is to slip a quarter wavelength balun made of flexible, shield braid over the matching transformer. The end of the braid should come within an inch or two of the joint between the 75 ohm line and the 150 ohm line. Tape both the end of the braid and the joint to prevent moisture troubles. Tape the braid every foot or so to keep it from pulling free of the line. Place the coaxial plug at the "transmitter end" of the balun, the shell of the plug being attached to both the balun braid and one side of the line, with the opposite side of the line attached to the center pin of the plug. Be careful not to melt the line insulation when you solder the connections.

Antenna Installation

The "Demi-Quad" array is quite light and may be handled by one small ham even though the wires seem to have a tendency to tangle themselves with every nearby object! For fixed operation in one direction (Northeast by Southwest, for example) the plywood center plate of the array may be bolted to the top of a TV-type mast, or a guyed pole made of 2″ x 2″ lumber. If it is desired to turn the antenna the centerplate can be bolted to two door hinges arranged one above the other on the pole. The free hinge plates are bolted to the supporting structure permitting the antenna to turn through nearly one hundred and eighty degrees. Since the beam pattern is very broad—about eighty degrees, effective—it is only necessary to turn the antenna through slightly more than ninety degrees to obtain effective coverage of all the DX-areas of the world. Because of the expense of any form of rotator it is recommended that the "Armstrong" method of turning be employed. Two ropes attached a few feet out on the lower crossarms will easily turn the array when you give a brisk tug to one. The ropes may also be used to hold the array in position so it will not be turned by the wind when you are working that elusive bit of DX. Good hunting with the "Demi-Quad"!

CHAPTER VIII

Five Dollar Beam Antennas!

Would you like a full size beam antenna for 10, 15, or 20 meters for a cost of about five dollars? Here's complete information on how to build two and three element parasitic beams out of wire and bamboo for a fraction of the cost of an aluminum tubing array! Delivering power gain equal to the more costly beams, these simple arrays may be built in a matter of minutes at an amazing low cost! Better build one now!

There's no doubt of it! The most popular amateur antenna in the world is the parasitic array. Two and three element "spinners" are commonplace in W-land and dot the landscape in many an exotic foreign QTH. In the dear, dead days of ample war surplus materials a three element all-aluminum array could be built for a few dollars. Now, with surplus stocks depleted a home built beam costs nearer sixty dollars than twenty, and a commercial beam costs nearer a hundred dollars than sixty. One fact is clear: no matter the cost or the method of construction, the full antenna gain will be realized if the array is built and adjusted in the proper manner.

After using all-aluminum rotary beam antennas since 1935, the author was abruptly confronted with the problem of antenna installation at his station in Monaco, 3A2AF. Notoriously known as a poor radio location because of surrounding hills and rocky cliffs, the tiny Principality was devoid of aluminum tubing except for bits and pieces imported and sold for staggering amounts. The price of tubing for a two element 20 meter beam ran well into three figures, and this was obviously out of the question! A few hours of operation with a dipole antenna proved that such a simple antenna was not capable of imparting enough "punch" to the signal to compensate for the poor radio location. Accordingly, experiments were conducted to see if a parasitic beam could be built out of material at hand. Copper antenna wire was not available so hard-drawn telephone wire was

"requisitioned" from a nearby telephone repair crew. Antenna insulators were cut from small blocks of wood and the supporting framework for the array was made of pieces of broom handles. The beam was flung up between two spindly supports after a few hours' feverish assembly. The results were actually astounding. The difficult "long path" to the West Coast of W-land (which heretofore had yielded one S-3 report out of many attempts at QSO) was now useable every day with S6-8 reports for 3A2AF. Stations as far "inland" as W2, W5, and W9 were worked via the 17,000 mile "long path" with relative ease. When reversed to "fire" the short path to the East Coast of the U.S.A. the puny beam did a fine job of forcing the signal over (or through!) the 2500 foot high sheer rock cliffs located about eight hundred feet northwest of the station. Results were so satisfactory with the 20 meter beam that 15 and 10 meter replicas were soon built for improved operation on those DX bands. These simple beams can be built for a few dollars apiece. If you have a good junk box at hand the cost will be even lower. For the utmost in simplicity and maximum results these wire arrays are highly recommended to any amateur!

Beam Design—Tubing Versus Wire

The parasitic beam consists of a dipole and one or more parasitic elements placed in close proximity to the dipole. Proper adjustment of the extra parasitic elements produces an antenna array having power gain concentrated in one direction at the expense of reduced power radiated in other directions. The array functions by virtue of inductive coupling between the parasitic elements and the radiator. Maximum power gain may be achieved by varying the length and spacing-to-the-dipole of the parasitic element. Power gains of up to four (6 decibels) may theoretically be obtained from two element parasitic arrays, and power gains up to nine (9 decibels) may be computed for three element arrays. In practice, gains slightly less than these figures are easily achievable.

Correct operation of the beam antenna is a function of the length of the elements, the spacing between them, and the diameter of the elements. Over a period of years the dimensions of parasitic arrays made of aluminum tubing have been optimized to produce highly efficient arrays exhibiting low SWR values on the transmission line, and capable of assembly and erection without complicated tuning adjustments. The length/diameter ratio of aluminum tubing elements is approximately 300/1 and most available data and formulas are based on elements having this ratio. Beam antenna elements made of wire, on the other hand, have length/diameter ratios of close to 5000/1. In addition, the wire elements must be supported from the tips by insulators that contribute a certain amount of capacitive effect to the elements. These two differences must be taken into account when

wire is substituted for larger diameter tubing in a parasitic antenna array.

In general, a resonant dipole decreases in length as the diameter of the element is increased. The length of a tubing dipole is usually about 97% of a free space half wavelength. The same dipole made of wire would average close to 98% of a half wavelength if it could be suspended in air with no end supports. When good glass insulators and rope are employed to support the wire dipole it will be found that the *end effects* of the supports more than compensate for the "thinness" of the wire and the net result is a dipole measuring close to 95% of a half wavelength. This indicates that the elements of a wire beam should be trimmed about 2% shorter than the elements of an equivalent beam made of aluminum tubing. The over-all operating efficiency of the two antennas, however, is equally high and one type will work as well as the other.

The radiation resistance at the dipole center of a properly tuned two or three element parasitic array is very close to 20 ohms. This is an awkward impedance to match to any of the available transmission lines which range in characteristic impedance from 50 to 300 ohms. Several types of matching systems may be employed with all-metal arrays but they are difficult to use with a wire antenna, especially if it is desired to hold the cost of the antenna to less than five dollars! A practical solution is to use a folded dipole as the driven element of the wire beam. A 4/1 step-up ratio can easily be achieved by this device, providing an almost perfect match to inexpensive "TV-type" 75 ohm balanced line. The use of a balun transformer at the "transmitter end" of the line provides an unbalanced termination suitable for the popular pi-network transmitter. Following this general design, a practical and efficient two or three element parasitic antenna system may be built that will equal the results obtained with the most expensive commercial antennas of the same type!

Antenna Construction

A general view of the wire beam is shown in figure 13. The elements of the antenna are made of wire fixed between two bamboo spreaders which in turn are suspended by a "bridle" of rope. Over-all antenna dimensions are small enough so that a three element beam is easily built for ten meters and may be built for fifteen meters if spreader arms of sufficient length can be found. Two element beams may be easily constructed for all three amateur bands. Let's take a two element 14 mc beam as an example of this type of construction and see how quickly it goes together!

The beam should be built in your driveway or other clear flat area, otherwise you will soon start to snarl yourself in a maze of various pieces

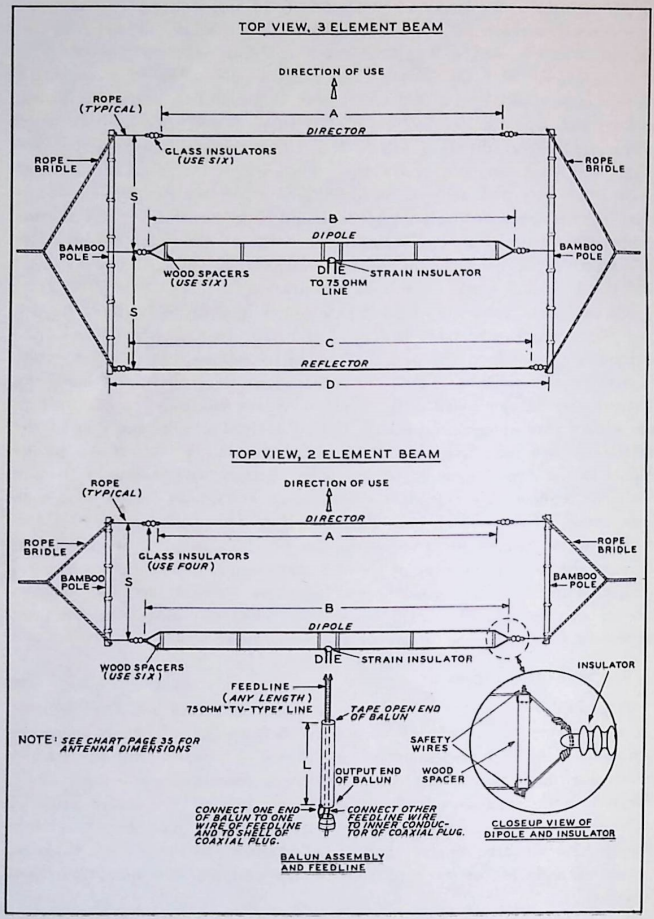


Fig. 13 Wire beams make efficient antennas for the higher frequencies. Overall length (D) is about two feet greater than reflector length (C). Beam should be mounted thirty to forty feet in air for best DX results.

of wire and bamboo. Begin the assembly by making the folded dipole first. For the twenty meter antenna the dipole length is 33'3" measured from insulator hole to insulator hole. Cut one piece of wire 34'6" long and clean the enamel insulation from each end of the wire. Loop the wires temporarily through the insulator holes, tie one insulator to your house or other support and give the other insulator several hearty tugs. This will take the kinks out of the wire and "pre-stretch" it. Now, remeasure the antenna and readjust the insulators to provide the correct length. The next step is to prepare the wooden insulators for the folded dipole. Six pieces of dry wood about 1"x3"x½" are needed. (My insulators were made from the end of an ancient packing crate!) Drill two small holes in the block to accommodate the antenna wires and give each block two coats of outdoor varnish. The six blocks are now strung along the antenna wire and the insulators are permanently positioned by wrapping the wire ends back upon themselves.

The second half of the folded dipole is now made. Two pieces of wire each 17'6" long are cut for this section. Clean the ends of the wire and attach one end of each wire to a strain insulator which will form the center termination point for the feedline. Stretch the wire as done previously to remove the kinks. Now, thread the wire through the wooden insulator blocks strung on the other half of the dipole so that three blocks are located on each side of the center insulator. In order to adjust the tension of the two wires it is necessary to string the folded dipole between two supports so that it is about shoulder high and under slight tension. Push the wooden blocks towards the center of the assembly to get them out of the way, making sure that the strain insulator is exactly opposite the center of the other dipole wire. This adjustment can be simplified by marking the center of the wire with a bit of plastic tape. When all is aligned, pass the second wire through the glass end insulators, looping the wire ends over the other wire and then twisting them back upon themselves, making a good electrical joint between the two dipole sections. You can now slide the outer blocks along the wires to their proper positions as shown in the drawing. Clean the dipole wires on each side of each block and loop the safety wires over the blocks, twisting the ends of the wires about the scraped portions of the dipole elements. Solder the safety wires in place and also solder the end joints of the antenna. Use a heavy duty iron or a small torch as the wires absorb heat as a thirsty sponge absorbs water. A well soldered joint, at each point of this antenna is essential! Clean wires, a hot iron, and rosin core solder will do the job.

You should next make the parasitic director wire. Cut a length of wire 32'6" long and clean both ends. Overall length of this element should be 31'3" from insulator hole to insulator hole. Solder the end joints. When the

elements are completed they should be attached to the wooden spreaders. Bamboo poles 1¼-inch diameter are best. Wrap each spreader between the joints with vinyl plastic tape to retard splitting and give the two poles a few coats of outdoor varnish or shellac. The two antenna elements are now attached to the tips of the spreaders by means of short lengths of clothesline, tied through the free insulator holes and looped and tied around the tips of the spreaders. Even though the director and folded dipole are different lengths the poles can be held at the right angles to the wires by varying the rope lengths between the insulators and the spreaders. The last step is to place a rope "bridle" across the ends of each spreader. The sides of the bridle and the spreader should form an equilateral triangle for best support.

If you tie a rope to the center of each bridle you can now sling the antenna between two low supports to see if everything looks ship-shape. The last step is to attach the ribbon feedline across the center insulator of the folded dipole. Strip the insulation from the line for six inches or so and pass the wires through the holes of the insulator, wrapping the wire ends around the dipole wires. Solder these joints securely with a hot iron. Finally, wrap the top of the line with a piece of vinyl plastic tape to prevent water and dirt from seeping down the wires.

The ten and fifteen meter beams may be constructed in a like manner, except that the three element arrays require a wire reflector which is slightly longer than the folded dipole. Follow the dimensions given in the illustration. For all antennas, the separation of the dipole wires is 2½-inches.

Installing the Antenna

The antenna is a unidirectional array radiating the major power lobe through the director at right angles to the wires. Because of the unique bridle support it is possible to flip the antenna over like a hammock, thus two directions (back to back) are available with a single antenna. For general DX work it is best to run the antenna in a Northwest-Southeast direction, covering the continent of Europe and the northern portion of Africa. When reversed, the antenna will blanket Australia, the mid-Pacific Islands and Southeast Asia. Two antennas at right angles to each other will do a pretty good job of world coverage as the useable pattern of the antenna is almost eighty degrees wide.

The beam requires a supporting point at each end. Two trees will do a good job, or your house and a single tree or pole. The antenna should be as high above the ground as possible, with a height of thirty feet an absolute minimum for any of the antennas. Below this elevation, you are not bouncing your signal into DX lands, but merely warming the worms in your yard!

Ropes attached to the ends of the bamboo spreaders will permit you to

reverse the antenna direction from the ground and will also help in steadying the antenna in a heavy wind. The folded dipole side of the array is heavier than the director side, and the two element beam tends to tilt up unless held in a horizontal position by the guy ropes. Make sure that your feedline drops vertically beneath the array for about twenty feet or so before you lead it off at an angle.

The Balun

Your last job is to make a suitable balun for the "transmitter end" of the 75 ohm "TV-type" transmission line. As in the case of the antennas previously described in this Handbook the balun consists of a quarter wave section of flexible shield braid slipped over the end of the transmission line. The line is first wrapped with a spiral of vinyl plastic tape and the braid is slipped over the tape and stretched out to its full length. It is trimmed to the proper dimension and held in place with a second spiral wrapping of tape over the entire balun. The open end of the balun is taped to cover the "whiskers" of wire. At the end of the line the balun shield is carefully soldered to a short length of wire which is attached to one wire of the transmission line and to the shell of the coaxial plug. The other wire of the line attaches to the center pin of the plug. The balun may be coiled up behind the transmitter or it may be used as part of the feedline running to the antenna.

For transmitter powers greater than 180 watts, heavy duty transmitting type 75 ohm transmission line should be employed in place of the lighter receiving type line. A final word: Use a great circle map and compass when you "aim" your antenna. You might be surprised at the direction taken by the Great Circle route! Good DX!

TABLE OF ANTENNA DIMENSIONS
FOR TWO AND THREE ELEMENT WIRE BEAMS SHOWN IN FIGURE 13

BAND	DIRECTOR (A)	DIPOLE (B)	REFLECTOR (C)	SPACING (S)	BALUN (L)
20	31' 3"	33' 1"	35' 2"	8' 0"	11' 0"
15	20' 10"	22' 1"	23' 6"	6' 6"	7' 8"
10	14' 10"	16' 0"	17' 4"	4' 0"	5' 6"

CHAPTER IX

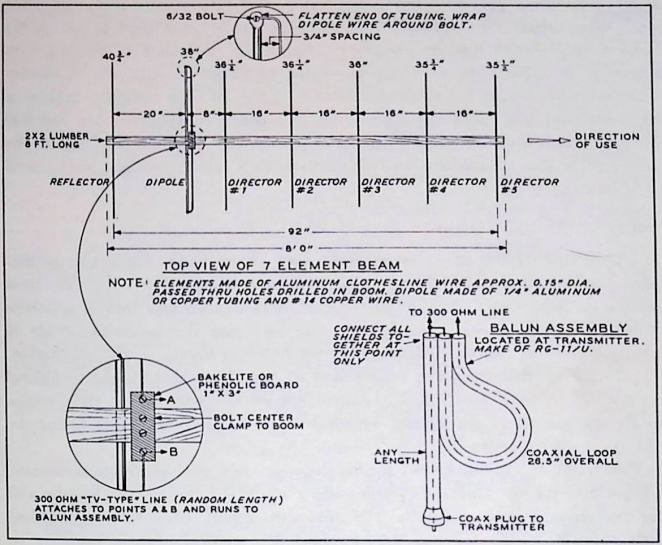
Gain Galore on 144!

Here's a 2 meter beam made of aluminum clothesline wire and wood! It will run rings around many an expensive 144 mc beam antenna. This midget monster (only eight feet long) has seven elements and provides a power gain of about 11 decibels! It will make a 90 watt transmitter sound like a full kilowatt, and boost received signals accordingly. You can build this powerhouse for less than five dollars!

The *Long Yagi* antenna has taken the VHF world by storm. Dollar for dollar and pound for pound it has consistently outperformed other types of arrays both for long distance and local work. The cost of an all-aluminum Yagi antenna unfortunately is not cheap and little information has been available covering construction of such antennas from less expensive materials. As an experiment, a simple 144 mc Yagi array was built of wood and copper tubing obtained from a refrigerator supply house. It worked so well a similar beam was built employing low cost aluminum clothesline wire in place of the tubing. It too performed in a satisfactory manner and the cost of all materials was only a few dollars. Here's the whole story of this thrifty antenna!

The Antenna Design

A seven element 144 mc beam optimized for maximum gain can be assembled on an eight foot boom. Coincidentally, the cost of an eight foot piece of 2"x2" lumber is less than a dollar. In addition, a large roll of heavy aluminum clothesline wire can be bought for less than a dollar! Putting these three facts together resulted in the design and use of a two meter array made of these inexpensive and easily obtainable materials. The complete Yagi array is shown in figure 14. The theoretical gain of 11 decibels seems to be achieved in the antenna which, when coupled to a



much modified surplus SCR-522 transmitter produced a "hole in the band" for far, far less money than an all aluminum array of the same size.

The beam employs a folded dipole, a parasitic reflector, and five parasitic directors. Element lengths and spacings are designed for maximum power gain consistent with complete coverage of the 144 mc band. The beam is fed with 300 ohm "TV-type" ribbon line, and employs a half wave balun transformer to provide an unbalanced 75 ohm termination suitable for use with most modern VHF transmitters.

The Folded Dipole

The radiation resistance of a Long Yagi array falls close to 20 ohms regardless of the number of elements in the array. A simple folded dipole will provide an impedance step-up of four to one giving a terminal impedance of about 80 ohms which is suitable for use with inexpensive 75 ohm "TV-type" ribbon line. Unfortunately this line which serves so well at the lower frequencies has quite a high transmission loss at two meters, one hundred feet of the line having nearly as much loss as the antenna provides in gain! Shifting to 300 ohm ribbon line drops the line loss to less

than 2 decibels per hundred feet of line, a figure much more reasonable and acceptable! The folded dipole can be readily modified to accept the higher impedance line by simply changing the diameters of the two conductors. A fifteen to one step-up ratio is obtained with the conductor diameters shown in the illustration, raising the 20 ohm radiation resistance of the array to a value approximating 300 ohms. Inexpensive, low loss 300 ohm line may now be used with the antenna, with a half wave balun at the transmitter end of the line to transform it to a low impedance, unbalanced termination.

Antenna Construction

The frame of the array is an eight foot boom made of a square section of 2"x2" lumber (which actually measures about 1½"x1½" in cross section). Sand down the lumber so that it is smooth and free of splinters. Round the edges with a knife or plane and give the boom two coats of outdoor varnish. Next, drill the element holes as shown in the illustration. The holes all lie along the center line of the boom and should be drilled on a drill press if possible to ensure that all elements are at right angles to the long axis of the boom. The holes should provide a tight fit for the aluminum wire elements.

The wire is now stretched tightly between two anchor points to remove all kinks from it. Cut it into element sections of the proper lengths and carefully round the tips of the elements with a file. When they are finished pass them through the wooden boom holes, centering them properly so that the array is square and true to the eye. After you have finished admiring your handiwork you should flatten the tips of the dipole element with a hammer and drill them to pass a 4-40 brass machine screw. Bolt the dipole wire to the aluminum element and coat the joints with a drop of nail polish to retard corrosion. Fasten the wires to the center clamp and the center clamp to the boom and the beam is complete. A word of caution: *Don't* paint the elements! They are very high-Q critters and a coat of paint will detune them badly. Leave them as they are and clean them to a bright polish every six months or so if required.

Positioning the Antenna

Height is the key to successful VHF antenna operation! Put your antenna up in the air as high as you possibly can. Keep it in the clear, free of nearby trees, branches, wires, and buildings which seem to absorb VHF waves all too readily. An inexpensive TV-style "slip-up" mast and a heavy duty TV rotator will make a nice installation to support the beam. Cheaper yet, a guyed wooden tower can be built for a few dollars and the beam can be turned by hand.

CHAPTER X

Six Meters in Six Minutes— 2 Elements on 50 Mc

You may not be able to build this simple 50 mc beam in six minutes but the small amount of time required will be more than compensated by the excellent results this midget array will deliver!

A dipole is a jolly antenna for 50 mc until the chips are down, then the power gain provided by the parasitic array leaves the dipole far behind in the race for DX contacts. It is possible to build a simple two element beam antenna for a few dollars that will produce big dividends in extended ground wave coverage and ionospheric DX for your six meter station. Here's how:

Antenna Design

The two element array employing a parasitic director provides more gain per unit of size than any other comparable amateur antenna. A simple pretuned array of this type can produce a power gain of about 4.8 decibels which is equivalent to a power increase from 10 watts to 30 watts. Best of all this power gain is also useful for receiving as well as transmitting!

Lady Luck smiles upon the 50 mc beam builder because the lengths of elements required for a parasitic array are all less than ten feet. This means that each element may be made of a single piece of tubing, requiring no splices or joints. Moreover, it is possible to use lengths of EMT aluminum tubing which is fabricated for use as electrical conduit and is quite inexpensive. The tubing is highly corrosion resistant, yet strong enough to

be self-supporting. You will need two ten foot lengths of ¾-inch tubing, obtainable at any large electrical supply house.

The radiation resistance of the beam is approximately 20 ohms and a folded dipole transformation ratio of 15/1 will permit a close match to a 300 ohm "TV-type" ribbon feedline. A simple halfwave balun at the far end of the line will provide a low impedance coaxial termination for your transmitter. A complete layout of the antenna is shown in figure 15.

Antenna Construction

The driven element and director are cut from two pieces of EMT aluminum conduit. The supporting boom of the array is made of a short length of dry 2"x2" lumber. The element crossarms are cut from pieces of 1"x2" lumber and are clamped to the boom by two angle brackets obtainable at any hardware store. One-eighth inch galvanized nuts and bolts are used for the assembly with flat washers placed between wood surfaces and the nuts and bolts. After a tight joint has been made the bolt threads should be crushed with a hammer to prevent the joint from working loose in a heavy wind.

Mount the director first. Drill matching holes through the crossarm and the element, then bolt the element directly to the arm using ⅛-inch galvanized bolts. The driven element is mounted to the other crossarm in the same manner. A small hole is drilled near each tip of the driven element and a #6 plated bolt is passed through the hole to which is attached the wire portion of the folded dipole made out of lengths of #8 plastic covered house wire. Each wire portion of the folded dipole should be supported at the mid-point by a small insulated spacer placed between the EMT tubing and the wire. You can make this spacer from a block of dry wood (well daubed with varnish or shellac), bakelite, or other insulating material. The wire should pass through a small hole drilled at the bottom of the block and the top of the block can be wired to the aluminum tubing. The center ends of the dipole wires are bolted to the insulated center block which also serves as a terminal support for the 300 ohm ribbon feedline. Finally, align the wires so they run parallel to the tubing and about two inches below it.

You can now attach the 300 ohm line to the antenna, wrapping the center joints well with vinyl electrical tape to retard corrosion. The beam is now ready to be hoisted into operating position. The last job is to make the simple balun which is placed at the "transmitter end" of the ribbon line. Remember to keep the feedline clear of nearby metallic objects and to allow it to drop vertically for twenty feet or so below the array before you bring it off at an angle to your transmitter.

The balun is made of a halfwave section of coaxial line and is more

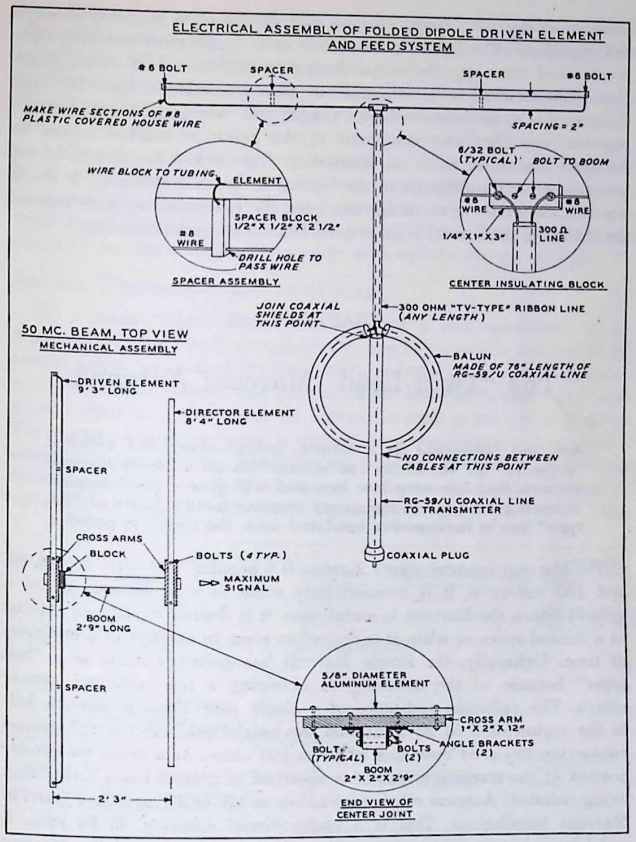


Fig. 15 Two element parasitic array is simple, inexpensive, and effective beam antenna for 50 mc operation. Antenna is composed of folded dipole and director, mounted on opposite ends of 2' 6" wooden boom. Dipole is fed with random length 300 ohm transmission line which is coupled to half-wave balun located near transmitter. The input impedance of the balun is about 72 ohms, so a 72 ohm coaxial transmission line may be run from the balun to the equipment. Beam is mounted with elements in horizontal plane.

exotic than the "sleeve-type" baluns used on the other antennas shown in this Handbook. The halfwave balun acts as a combination matching transformer and balancing device, producing an unbalanced 75 ohm termination when attached to a balanced 300 ohm transmission line. The three outer shields of the balun ends and coaxial line (any length) are connected together, and the inner conductor of the balun is attached across the balanced line as shown in the illustration. The coaxial line can be of any convenient length, although in the interest of greatest efficiency it should not be more than ten or twelve feet long. No connection is made between the shields of the coaxial lines and the balanced transmission line.

CHAPTER XI

The "Twin Lead" Marconi Antenna

Are you interested in a simple, inexpensive, and efficient "sky-wire" for 40, 80, or 160 meters? Here's a simple Marconi antenna that has very low loss and will give a good account of itself on the lower frequency amateur bands. Made of "TV-type" line or inexpensive insulated wire, the cost is in pennies.

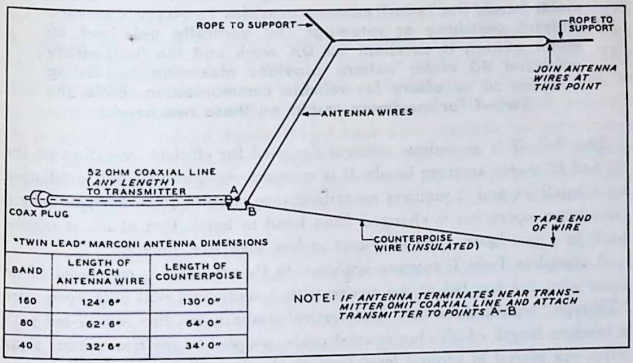
The Marconi (quarter wave) antenna is a popular "sky wire" for 40, 80, and 160 meters as it is comparatively small in size. Making use of a ground return the Marconi is useful when it is desired to erect an antenna in a limited space or when it is desired to erect an antenna in a minimum of time. Unhappily, the simple Marconi has gained a name as a "bad actor" because of the difficulty of obtaining a low resistance ground return. The radiation resistance of a single wire Marconi antenna falls in the region of 5 to 20 ohms and the usual "quick and dirty" ground connection has a r-f resistance of 10 to 100 ohms. As a result the greater portion of the transmitter power is absorbed in ground losses rather than being radiated! Antenna efficiencies as low as 1% or 2% are often found in Marconi installations. This is a pretty dismal situation, to be sure. A satisfactory solution is to boost the radiation resistance of the Marconi antenna to a more reasonable value close to 50 ohms or so. This can be done by applying the folded dipole principle, permitting an impedance stepup of 4/1 to be achieved. A "folded Marconi" such as shown in figure 16 exhibits a radiation resistance of about 48 ohms at the feedpoint, with an overall efficiency of about 40% if a fairly good ground connection is

used. With a little more thought given to the ground connection, radiation efficiencies of the order of 70% are achievable. The "tuned ground" or *counterpoise* is the ideal solution to this problem.

The counterpoise is a quarter wavelength insulated wire run close to the surface of the ground. No connection is made between the wire and the ground. The wire may lay on the grass, weave around bushes and trees, or trail across the lawn. The capacity between the wire and ground effectively forms a low impedance point at the "transmitter end" of the counterpoise. In more elaborate installations the counterpoise takes the form of many wires stretched a few inches above the ground. This is "first class" but not necessary for this simple antenna. One wire will do the job nicely!

Antenna Construction and Installation

The simplest "folded Marconi" consists of a half wavelength of insulated wire doubled back upon itself. One end of the wire is attached to the coaxial output terminal of the transmitter, and the other end is grounded to the transmitter chassis. The far end of the Marconi is tied to a length of rope which is used to hoist the antenna as high in the air as possible. The quarter wave counterpoise is draped along the ground and one end is attached to the transmitter chassis as shown in the illustration. An attempt should be made to keep the two wires of the antenna parallel to each other and not more than six inches apart. Light wooden spacers tied to the wires


ROPE TO SUPPORT
ROPE TO SUPPORT
JOIN ANTENNA WIRES AT THIS POINT
ANTENNA WIRES
52 OHM COAXIAL LINE (ANY LENGTH) TO TRANSMITTER
A
B
COAX PLUG
TAPE END OF WIRE
COUNTERPOISE WIRE (INSULATED)
"TWIN LEAD" MARCONI ANTENNA DIMENSIONS
NOTE: IF ANTENNA TERMINATES NEAR TRANSMITTER OMIT COAXIAL LINE AND ATTACH TRANSMITTER TO POINTS A-B

BAND	LENGTH OF EACH ANTENNA WIRE	LENGTH OF COUNTERPOISE
160	124' 6"	130' 0"
80	62' 6"	64' 0"
40	32' 6"	34' 0"

Fig. 16 Folded Marconi antenna made of "TV-type" twin lead gives good account of itself on the low frequency bands. Ground losses are reduced and efficiency is raised over simple single wire Marconi to about 70 per cent.

with string will do the job. A more sophisticated installation can be made of a quarter wave piece of 300 ohm "TV-type" ribbon line. The far end of the line is shorted together and attached to an insulator.

A word of warning: When a simple antenna of this type is used there exists a great temptation to hang it to the nearest bush and get on the air as rapidly as possible. As with any antenna, the "folded Marconi" works best when it is erected as high in the air as possible. With the aid of heavy twine and a rock you can easily hoist the far end to the uppermost branches of a handy tree. A second string tied about the midpoint will permit the antenna to be strung up in a horizontal position. Time spent in jockeying the antenna into the best possible position will pay big dividends in signal reports. Placement of the counterpoise is not particularly critical.

CHAPTER XII

The "Twin-T" Antenna for 40 and 80 Meters

Simple and inexpensive? Yes! Designed for the 40 and 80 meter bands the Twin-T antenna provides two-band operation without switching or retuning! The vertically polarized 80 meter pattern is excellent for DX work and the horizontally polarized 40 meter pattern provides maximum anti-fading qualities so necessary for reliable communication. Build the Twin-T for maximum results on these two bands!

The Twin-T is an unique antenna designed for efficient operation on the 40 and 80 meter amateur bands. It is compact enough to permit installation on a small lot and it requires no critical trap circuits or switching mechanisms when operation is changed from band to band. Best of all, it can be built in a few hours time at a cost of less than five dollars!

A complete Twin-T antenna is shown in figure 17. It is composed of an open wire flat top fed at the center with a section of 450 ohm open wire "TV-type" transmission line. The vertical transmission line is base-fed with a random length of 52 ohm coaxial cable, coupled to the transmitter. Four wires are placed at ground level beneath the Twin-T antenna to serve as a simple counterpoise (ground) system. Now, before you grab your soldering iron, let's examine the action of this unusual antenna array and investigate the manner whereby it works efficiently on both the 40 and 80 meter bands.

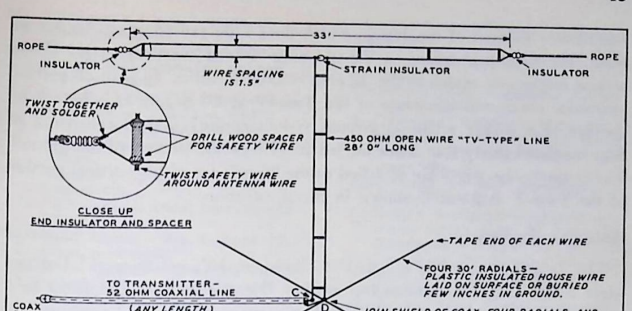

33'
ROPE
INSULATOR
WIRE SPACING IS 1.5"
STRAIN INSULATOR
INSULATOR
ROPE
TWIST TOGETHER AND SOLDER
DRILL WOOD SPACER FOR SAFETY WIRE
450 OHM OPEN WIRE "TV-TYPE" LINE 28' 0" LONG
TWIST SAFETY WIRE AROUND ANTENNA WIRE
CLOSE UP END INSULATOR AND SPACER
TAPE END OF EACH WIRE
FOUR 30' RADIALS— PLASTIC INSULATED HOUSE WIRE LAID ON SURFACE OR BURIED FEW INCHES IN GROUND.
TO TRANSMITTER— 52 OHM COAXIAL LINE
(ANY LENGTH)
COAX PLUG
C
D
JOIN SHIELD OF COAX, FOUR RADIALS, AND ONE WIRE OF "TV-TYPE" LINE AT POINT D

Fig. 17 "Twin-T" antenna functions on two low frequency amateur bands. Four radial wires (vinyl plastic covered house wire) run along surface of ground to provide counterpoise system. Wires may be buried, if desired.

40 Meter Operation

The flat top (horizontal) portion of the Twin-T antenna consists of a 7 mc dipole with the ends bent back upon themselves reducing the overall length of the dipole to one-quarter wavelength. The impedance between the tips of the dipole (A-B, figure 17) is of the order of 6,000 ohms. This flat top portion of the antenna looks like a folded dipole but it is not, as it does not have the current distribution of the simple folded dipole antenna. It is actually an end-fed dipole, folded back upon itself to conserve space, Since the center portion of the dipole has the maximum value of antenna current flowing in it and therefore contributes the major portion of the radiated field, folding the ends back does not appreciably diminish the effectivity of the antenna.

The vertical portion of the Twin-T (AB-CD, figure 17) acts as a 450 ohm quarter wave transformer to match the 6,000 ohm termination of the horizontal antenna to the 52 ohm characteristic impedance of the coaxial transmission line. In this fashion the Twin-T presents a well matched picture, suitable for operation across the complete 7 mc band.

80 Meter Operation

On the 80 meter band the Twin-T antenna resembles a top loaded vertical radiator, fed in one leg. The loading effect is provided by the horizontal

(40 meter) portion of the system which does little radiating on the 3.5 mc band. The step-up provided by the two wire "folded" vertical section allows a close impedance match to the 52 ohm coaxial feedline. As with all vertical antennas, maximum efficiency of the Twin-T at 80 meters is achieved by the use of a simple artificial ground (counterpoise) system consisting of four insulated thirty foot wires buried just below the surface of the ground. The counterpoise wires are attached to the "free"wire of the vertical portion of the Twin-T at point D shown in the illustration.

Antenna Assembly

The Twin-T antenna is a "snap" to build, so let's get to work! Cut two wires 34'6" long for the flat top section. Tie the ends of the wires to a sturdy support and give the free end of each a husky tug to remove the kinks and to "pre-stretch" the wire. Cut one wire at the center, scrape the ends carefully with a knife blade to remove the enamel and temporarily attach them to two glass insulators, allowing 33'0" of wire between the insulator eyes. Make sure the strain insulator you place at the center of the broken wire falls at the exact center of the other wire. If you do this job with the antenna temporarily slung between two handy supports it will be a simple and uncomplicated task.

Your next step is to make six wooden spreaders that will hold the flat top wires at the desired 2-inch separation. Cut the blocks to a size of about 2" x 1" x ½" and give them a coat of varnish or shellac. Drill the ends of each block to pass a small safety wire. Now, put the blocks in position on the wires and lash them in place with short pieces of safety wire. Stretch the antenna tight between the two supports and (after making sure that everything is ship-shape) fasten the end insulators firmly in place and solder the joints. The last job is to cut the 450 ohm "TV-type" open wire line to the proper length and solder the end wires across the center strain insulator of the flat top. You can erect the antenna in the air now, as your only remaining bit of work is to complete the radial system and coaxial lead-in.

The "Scotsman's Dipole" (page 10).
2—Glass insulators.
1—Strain insulator. Birnbach #463.
1—Length #12 enameled copper wire (see text).
1—Length 75 ohm "TV-type" ribbon line (see text). Belden #8222.
1—Length ¼"-diameter copper braid shielding (see text). Belden #8663.
1—Coaxial plug to match your transmitter.
1—Roll vinyl electrical tape. Scotch #33.

Multi-band Antenna (fig. 4, page 13).
6—Glass insulators.
1—Strain insulator. Birnbach #463.
1—Length #12 enameled copper wire, 225 feet.
1—Length 75 ohm "TV-type" ribbon line (see text). Belden #8222.
1—Length ¼"-diameter copper braid shielding, 22 feet. Belden #8663.
1—Coaxial plug to match your transmitter.
1—Roll vinyl electrical tape. Scotch #33.

Multi-band Antennas (fig. 5, page 14).
6—Glass insulators.
1—Strain insulator. Birnbach #463.
1—Length #12 enameled copper wire, 85 feet.

Multi-band Antennas (fig. 6, page 15).
4—Glass insulators.
1—Strain insulator. Birnbach #463.
1—Length #12 enameled copper wire (see text).
1—Length ½"-diameter copper braid shielding (see text). Belden #8669.
1—Length 75 ohm "TV-type" ribbon line (see text). Belden #8222.
1—Coaxial plug to match your transmitter.
1—Roll vinyl electrical tape. Scotch #33.

Multi-band Antenna (fig. 7, page 17).
2—Glass insulators.
1—Strain insulator. Birnbach #463.
1—Length 4-wire vinyl plastic antenna rotor cable, 45 feet. Amphenol #214-298.
1—Length 75 ohm "TV-type" ribbon line (see text). Belden #8222.
1—Length ½"-diameter copper braid shielding, 40 feet. Belden #8669.
1—Coaxial plug to match your transmitter.
1—Roll vinyl electrical tape. Scotch #33.

Multi-band Ground Plane Antenna (page 19).
1—Length lumber, 2"x2"x16', well dried.
1—Length #12 enameled copper wire, 40 feet.
5—"TV-type" universal stand-off insulators. Telco #8027 wood screw, 3½" long. General Cement Mfg. Co.
1—Ceramic standoff insulator. Birnbach #866.
1—Length 4-wire vinyl plastic antenna rotor cable, 52 feet. Amphenol #214-298.
1—Length 52 ohm coaxial line (see text). RG-8/U or RG-58/U. Amphenol.
1—Coaxial plug to match your transmitter.
3—Glass insulators.

Cobra Ground Plane Antenna (p. 23).
1—Glass insulator.
1—Length #12 enameled copper wire (see text).
1—Length 52 ohm coaxial line (see text). RG-8/U or RG-58/U. Amphenol.
1—Wood dowel rod, 1"x1"x15".
1—Coil form (see text), ¼" plywood.

"Quick and Easy" Dipole (page 25).
1—Length "twisted pair" electrical wire (see text).
1—Set wooden spreaders (see text).
1—Coaxial plug to match your transmitter.

"Demi-Quad" Beam Antenna (p. 27).
1—Length #12 enameled copper wire (see text).
4—Bamboo poles, dry and free of splits. Use 12' poles for 20 meters.
8—Galvanized "TV-type" U-bolts, 1½" size. Kenco "Mast joiner," or equivalent.
1—Strain insulator. Birnbach #463.
1—Center plate, plywood, 12"x12"x½".
1—Length "TV-type" 150 ohm line (see text). Amphenol #14-079.
1—Length "TV-type" 75 ohm ribbon line (see text). Belden #8222.
1—Length ¼"-diameter copper braid shielding (see text). Belden #8663.
1—Coaxial plug to match your transmitter.
1—Roll vinyl electrical tape. Scotch #33.

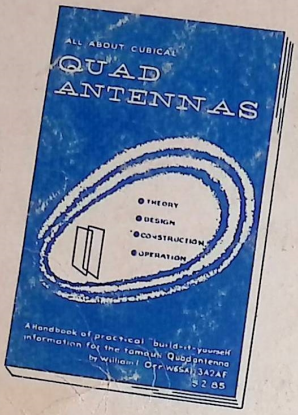
Five Dollar Beam Antennas (page 32).
1—Length #12 enameled copper wire (see text and chart, page 35).
6—Glass insulators. (Only 4 required for two element beam).
1—Strain insulator, Birnbach #463.
2—Bamboo poles, dry and free of splits. (See text and chart, page 35).
1—Length "TV-type" 75 ohm ribbon line (see text). Belden #8222.
1—Length ¼"-diameter copper braid shielding (see text). Belden #8663.
1—Coaxial plug to match your transmitter.
6—Wood spreaders (see text).
1—Length of ½" rope for bridles and support.

Gain Galore on 1441 (page 37).
1—Length lumber, 2"x2"x8', well dried.
1—Length aluminum clothesline wire, 20 feet.
1—Length ¼"-diameter aluminum tubing, 3'2" long.
1—Length #14 enameled copper wire, 40" long.
1—Bakelite or phenolic board 1"x3"x⅛".
1—Length 300 ohm "TV-type" ribbon line (random length). Belden #8235.
1—Length 72 ohm coaxial line, RG-11/U. (Balun and coaxial line to transmitter, see text).
1—Coaxial plug to match your transmitter.

Six Meters in Six minutes (page 41).
2—Lengths ¾" aluminum EMT tubing, 10' long.
1—Length #8 solid copper plastic covered house wire, 10' long.
1—Insulating block, 1"x3"x¼", phenolic.
1—Length 300 ohm "TV-type" ribbon line (random length). Belden #8235.
1—Length 72 ohm coaxial line, RG-59/U. (Balun and coaxial line to transmitter, see text).
2—Wood crossarms, 1"x2"x12".
4—Galvanized angle brackets, 2"x2".
1—Coaxial plug to match your transmitter.
1—Roll vinyl electrical tape. Scotch #33.
1—Wood boom, 2"x2"x2'6", well dried.
2—Wood spacer blocks, ½"x½"x2½".

"Twin Lead" Marconi Antenna (p. 43).
1—Length 300 ohm "TV-type" ribbon line (see text). Belden #8225.
1—Length #12 vinyl insulated house wire (see text).
1—Length 52 ohm coaxial line, RG-8/U (see text).
1—Coaxial plug to match your transmitter.

"Twin-T" Antenna for 40 & 80 Meters.
1—Length #12 enameled copper wire, 70' long.
1—Length 450 ohm open wire "TV-type" transmission line, 28' long. National Wire Co. #N-470-1.
1—Length #12 vinyl insulated house wire, 120'.
1—Length 52 ohm coaxial transmission line, RG-8/U, (see text).
1—Coaxial plug to match your transmitter.
6—Wood spacer blocks ½"x½"x2".
2—Glass insulators.
1—Strain insulator. Birnbach #463.



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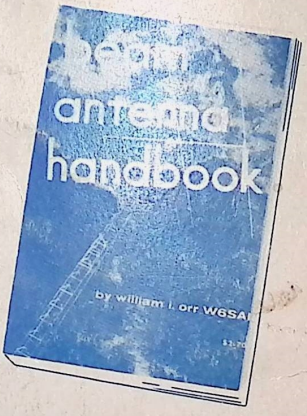

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